UNIT I OPTICAL FIBRES & THEIR PROPERTIES

PART A

1.What is incident and reflected light?

Incident Light:Light approaching a surface is known as incident light. This is the incoming light before it has reached the surface.

Reflected Light:After light has struck a surface and bounced off, it is known as reflected light. This is the light that is now departing from the surface.

2. What is angle of incidence?

Angle of incidence: The angle between an incident ray and the normal to a reflecting or refracting surface. The angle at which a ray of light approaches a surface, reflective or not, is called the angle of incidence. It is measured from an imaginary line perpendicular to the plane of the surface in question to the incoming ray of light.

3. What is Angle of Reflection?

Angle of Reflection : Once the light has reflected from a reflective surface, the angle at which the light departs from the surface is called the angle of reflection. This angle is also measured from a perpendicular to the reflecting surface to the departing ray of light. When light reflects from a surface, the angle of reflection is always equal to the angle of incidence.

4. Define critical angle?

In geometric optics, at a refractive boundary, the smallest angle of incidence at which total internal reflection occurs. The angle of incidence is measured with respect to the normal at the refractive boundary.The critical angle is given by where c is the critical angle, n 1 is the refractive index of the less dense medium, and

n2 is the refractive index of the denser medium.

Note: The incident ray is in the denser medium.

Note : If the incident ray is precisely at the critical angle, the refracted ray is tangent to the boundary at the point of incidence.

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5. What is fiber optics?

Fiber optics is a medium for carrying information from one point to another in the form of light. Unlike the copper form of transmission, fiber optics is not electrical in nature. A basic fiber optic system consists of a transmitting device, which generates the light signal; an optical fiber cable, which carries the light; and a receiver, which accepts the light signal transmitted. The fiber itself is passive and does not contain any active, generative properties.

6. What is bandwidth and wavelength?

Bandwidth: Measure of the information-carrying capacity of an optical fiber

Wavelength: The distance between two successive points of an electromagnetic waveform, usually measured in nanometers (nm)

7. What is total internal reflection?

The reflection that occurs when light, in a higher refractive-index medium, strikes an interface, with a

medium with a lower refractive index, at an angle of incidence (with respect to the normal) greater than the critical angle. When a light ray traveling in one material hits a different material and reflects back into the original material without any loss of light, total internal reflection occurs.
Since the core and cladding are constructed from different compositions of glass, theoretically, light entering the core is confined to the boundaries of the core because it reflects back whenever it hits the cladding. For total internal reflection to occur, the index of refraction of the core must be higher than that of the cladding.

8. Define waveguide?
A material medium that confines and guides a propagating electromagnetic wave. In the optical regime, a waveguide used as a long transmission line consists of a solid dielectric filament (optical fiber), usually circular in cross section. In integrated optical circuits an optical waveguide may consist of a thin dielectric film.

9. What are the three basic parts of a optical fiber?
The CORE, CLADDING, and COATING or BUFFER are the three basic parts of an optical fiber.

10. What are the two basic modes of fibers?
Fibers are classified by the number of modes that propagate along the optical fiber. Single mode fibers propagate only one mode because the core size approaches the operational wavelength. Multimode fibers can propagate over 100 modes depending on the core size and numerical aperture.

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11.What is acceptance angle and acceptance cone?
The maximum angle 'θa' with which a ray of light can enter through the entrance end of the fiber and still be totally internally reflected is called acceptance angle of the fiber .The light ray incident on the fiber core must be within the acceptance cone defined by the acceptance angle to be propagated along an optical fiber.

12. What is macro bending?
If a bend is imposed on an optical fiber, strain is placed on the fiber along the region that is bent. The bending strain will affect the refractive index and the critical angle of the light ray in that specific area. As a result, light traveling in the core can refract out, and loss occurs. A macrobend is a large-scale bend that is visible.

13. What is Microbending? This is a small-scale distortion, generally indicative of pressure on the fiber. Microbending may be related to temperature, tensile
stress, or crushing force. Like macrobending, microbending will cause a reduction of optical power in the glass. Microbending is very localized, and the bend may not be clearly visible upon inspection. With bare fiber, microbending may be reversible; in the cabling process, it may not.

14.What is a decibel?
Unit for measuring the relative strength of light signals. Normally expressed in dB, it is equal to one-tenth the common logarithm of the ratio of the two levels. Expressed in dBm when a power level is compared to a milliwatt.

15. What is Zero-Dispersion Wavelength?
Wavelength at which the chromatic dispersion of an optical fiber is zero; occurs when waveguide dispersion cancels out material dispersion.

16.Among microwaves and light waves, which have high bit rate distance product? Why?
Light waves have high bit rate distance product because light waves have high frequency (1014hz) than microwave frequency (1011hz) and information carrying capacity of an electromagnetic wave is directly proportional to its frequency.

17. Mention three specific communication based advantages of optical communication?
1. Due to frequency of light, more number of data can be sent per second. 2. Light waves have increased antenna gain or high s/n ratio since the signal energy received at the receiver is directly proportional to square of carrier frequency. 3. Light waves require antenna with small size due to their short wavelengths. 4. Light waves have negligible divergence due to smaller wavelengths.

18. Mention three advantages of optical fiber as waveguide over conventional metallic waveguide?
1. Optical fiber is made up of dielectric (glass) so there is no electromagnetic interference or cross talk.
2. Optical fiber cable is in small size with less weight. Hence it is flexible and it can be laid at any place without any congestion.
3. Optical fiber has low transmission loss. The transmittal signal through the fibers dose not radiate like metallic conductors.

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19. What are the important elements in any communication system?
1. Transmitter to transmit the modulated carrier which carries information.
2. Transmission channel to carry to modulated carrier from one point to another point without loss and dispersion.
3. Receiver to detect or to separate the signal from carrier.

20. What is the necessity of cladding for an optical fiber?
a) To provide proper light guidance inside the core. b) To avoid leakage of light from the fiber. c) To give mechanical strength for the fiber. d) To protect the core from scratches and other mechanical damages.

UNIT-I

OPTICAL FIBRES AND THEIR PROPERTIES.

1) Describe the different types of fibers and their properties with neat sketches.

Optical fibre - dielectric wave guide that operates at optical frequencies.

Normally cylindrical in form.

Types of fibres: step index fibre, Graded index fibre

- * Single mode
- * Multimode
- * multi mode

Step index - Refractive index of core is maximum.

↓ of " " in cladding.

$\Rightarrow n_2 = n_1 (1-\Delta)$

Graded index - refractive index of core varies parabolically

max at core axis min - core cladding boundary

$\Rightarrow n(r) = n_1 [1-2\Delta]^{1/2}$ for $r \geq a$

$\Rightarrow NA = n_1 \sqrt{2\Delta}$.

2) Define & Explain (i) Numerical Aperture (ii) Acceptance cone (iii) Total internal reflection.

Total internal reflection - When light ray incident on interface b/w two medium having diff. indices angle > critical angle

diagram.

Light gets totally internally reflected.

$\Rightarrow \frac{\sin\phi_1}{\sin\phi_2} = \frac{n_2}{n_1}$.

Acceptance cone: Acceptance angle - max. angle to the axis at which light may enter the fibre. any ray incident > θ_c

$\Rightarrow$ Core cladding interface < ϕ_c.

Numerical Aperture: light collecting efficiency

measure of amount of light rays

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$\Rightarrow n_1 > n_2$.

Snell's law, $n_0 \sin\theta_1 = n_1 \cos\phi$.

$\Rightarrow n_0 \sin\theta_\alpha = (n_1^2 - n_2^2)^{1/2}$

Relative refractive index diff b/w core and cladding.

$\Rightarrow NA = n_1 (2\Delta)^{1/2}$

3) Enumerate and explain the requirements of an optical source and an optical detector.

Optical source :
- Must emit the required wavelengths of 1.3 μm & 1.55 μm in case of silica fibre
- Spectral line - Small, dispersion & Spectral line width
- Compact size, high efficiency
- Reliable, durable, inexpensive
- Require small time for operation.

Optical detector :
- High Quantum efficiency η
- Low dark current
- Signal dependant noise should be low

4) Define and explain (i) Absorption losses, (ii) Scattering losses (iii) Dispersion.

Absorption losses - By atomic defects - Glass material
- Extrinsic - impurity atoms - " "
- Intrinsic - Basic atoms - fibre material.

Scattering losses -
- Linear scattering - Rayleigh, Mie
- Nonlinear - Stimulated Brillouin scattering, Stimulated Raman

Dispersion : Broadening of signal pulse width
- Intramodal dispersion
- Intermodal dispersion.

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5) Difference between Step index and Graded index fibre.

Step index	Graded index
* Refractive index of core - uniform	Vary in parabolic manner.
* Diameter of core. - 50 to 200μm	50μm.
* Light rays - meridional rays	Skew (or) helical rays.
* BW - 50MHz.	200 MHz to 600 MHz.
* Attenuation - more	less
* Numerical Aperture - more	less.
* Signal distortion - more	Signal distortion - very low

6) Difference between single mode & multimode fibre.

Single mode	Multimode
* Only one mode propagate	Large no. of paths.
* Core diameter smaller	large.
* No dispersion	There is signal degradation
* Long distance communication	Local Area network
* Launching - difficult	easy.
* Fabrication - " , costly	Less difficult, Not costly.

7) Explain the two important characteristics of optical fibres.

Mechanical characteristics.
* Strength * fatigue (Static) * Dynamic fatigue
⇒ $K = Y \lambda^{1/2} \sigma$

Transmission characteristics.
* Absorption losses
* Scattering "
* Dispersion
⇒ $\alpha_{dB} = 10 \log_{10} P_i / P_o$

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8) Discuss the principle of splicing technique.

Splices – permanent joint b/w two individual optical fibre

* fusion splicing – applying localised heating
* Mechanical splicing – Alignment by some mechanical means

Necessary → Used to establish long haul optical fibre

Diagram for splices.

9) Define (i) Mechanical splicing (ii) fusion splicing

Mechanical splicing – Alignment by some mechanical means

* capillary type
* Elastic groove type
* V Groove type
* Sprig groove type

fusion splicing – Applying localised heating

* Arc fusion process ✓ Diagram ④.
* Per fusion.

10) What are the type of connectors explain in detail with neat diagram.

Connectors – * Removable joints which allow easy, fast manual coupling of fibres.

* Low coupling losses
* Not affected by temperature

Types :- * Butt joined connector. ⇒ Cylindrical ferrule connectors
Double eximus "

* Expanded beam connectors.

⇒ Consists of two lenses for collimating & refocussing the light from one fibre to other.

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